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THE URAL MINERAL RAW-MATERIAL BASE FOR THE CERAMICS, REFRACTORY, AND GLASS INDUSTRY

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Brief information is reported on the promising deposits of clays and kaolins, feldspars and their substituents, quartz minerals, carbonate rocks, pyrophyllites and kyanites, magnesia and magnesia-silicate materials, and many other types of raw materials for the ceramics, glass, and refractories industry.

The Ural is rich in almost all kinds of natural mineral raw-material resources for the ceramics, refractory, and glass industry. Important reserves of both refractory and high-melting clays, high-quality kaolins, and large reserves of other kinds of nonmetalliferous raw materials are concentrated in the region.

The richness and variety of Ural mineral resources make it pressing to research and produce new kinds of mineral raw materials and technologies for processing them. Approximately half of the reserves of refractory clays out of all proven deposits in the Russian Federation is concentrated in the territory of the Ural. More than 200 refractory and high-melting clay deposits have now been discovered in the Ural.

With respect to the quality and reserves, the Belkino, Kur'insk, and Troitsko-Bainov (Bogdanovich) deposits of refractory clays in the Central Ural dating back to the Cretaceous period are very important for the refractory industry. These deposits serve as raw-material bases for the refractory works of the Nizhnetagil Metallurgical Combine, Bogdanovich Refractory, and Sukholozhsk Chamotte Works.

Valuable refractory clay deposits from the Tertiary period are located on the eastern slope of the South Ural – Nizhneuvel, Yuzhnoural'sk (Berlinsk), Buskul'sk, and Kumaksk. Both with respect to reserves and with respect to quality, Tertiary period refractory occupy one of the top positions in the Russian Federation and CIS countries. Total production at the seven large Ural refractory clay deposits is more than 200 million tons a year. Then 29.6% of all Russian reserves is concentrated in two worked refractory clay deposits with the balance over the Chelyabinsk oblast (Nizhneuvel and Yuzhnoural'sk), and the volume consists of 44.1% of all production in the country.

The Ural has little high-melting clay (1.3%). There are few deposits of high-melting clays and the reserves are small in volume. The largest deposit of high-melting clays – the Talalaevsk (Republic of Bashkortostan) – has reserves of approximately 3 million tons.

In addition to these deposits of refractory and high-melting clays in the Ural, there are many clay deposits which are important with respect to reserves; the possibility of using them in production of ceramics and refractories has not been established.

The Troitsko-Bainov (Bogdanovich) refractory clay deposit is the largest in the Central Ural with respect to the size of the reserves. Many tests suggest a large quantitative variety of clays in the deposit – from high-alumina low-iron varieties to very sandy and contaminated primarily with pyrite, iron oxides and organic matter.

The light varieties of clays, white and light grey (rarely dark grey), have a high alumina content and an insignificant amount of contaminants (pyrite, sphaerosiderite, sand), are finely disperse with grease milling, and their refractoriness is 1750°C and higher. Clays of darker hues (from dark grey to black) are much sandier, ferruginous, and contain a large amount of pyrite inclusions, and primarily lie in low levels. As a function of the grain size and contaminant and Al_2O_3, the clays are classified as basic, semiacid, and carbonaceous. The clays are characterized by medium plasticity and important dispersion (the content of particles less than 1 μm in size is 60 – 90%). The clays vary in chemical composition: the $Al_2O_3 + TiO_2$ content varies from 15 to 42%,[2] the Fe_2O_3 content varies from 0.5 to 7%, and the loss on calcination ranges from 4 to 18%. The clays sinter at high temperatures (1300 – 1400°C) and their refractoriness varies from 1610 to 1760°C.

In mineral ratio, the clays are kaolin-quartz. The refractory clays in the Poldnevsk deposit (the predominant type) consist of kaolinite, and the clays from the Mezhnikov deposit consist of kaolinite with montomorillonite contaminant.

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[2] Here and below – mass content.

The Kur'insk refractory clay deposit is characterized by great inconstancy and variability of the quality. Fat plastic clays insignificantly turn into lean sandy clays and argillaceous sands. With respect to the petrographic composition, the clays have different ratios of argillaceous matter, quartz sand, mica, marcasite, pyrite, sphaerosiderite, limonite, gypsum, and carbonized plant residues. Marcasite both in the form of radiant-spherical aggregates of kidney-shaped concretions 20 mm in diameter and in the form of a finely pulverized disseminations is characteristic of Kur'insk refractory clays.

With respect to quality, important fluctuations from high-alumina varieties free of contaminants to highly sandy clays significantly contaminated with grey pyrite with sphaerosiderite oolites and brown iron oxides are characteristic of Kur'insk clays.

The mineral composition of Kur'insk clays is somewhat varied as they contain kaolinite, quartz, muscovite, rutile, zirconium, tourmaline, feldspar (orthoclase), biotite, andalusite, pyrite, and sphaerosiderite. The content of particles smaller than 1 μm is 42 – 62%. The plasticity of the clays is higher than average.

The sintering temperature is 1300 – 1400°C and the refractoriness is 1580 – 1750°C. Kur'insk clays are less sensitive to drying than Troitsko-Bainov clays, while the rest of their properties are similar.

Kur'insk clays can be used for production of stoneware, saggers, and if washed, for manufacturing faience.

Kur'insk clays in the Bereznyak section have an unusually high Al_2O_3 content and high refractoriness. They are of interest to the refractories and ceramics industries. These highly plastic clays are grey and after firing at 1330 – 1350°C, they turn yellow-white with rare small "specks," cracks, crazing, and high porosity. The results of comprehensive testing of the clays showed that they are hydrargillite and difficultly sinterable. The clays from the Bereznyak section are valuable high-alumina raw material for production of high-alumina refractories and ceramic ware for demanding applications.

Refractory clays from the Belkino deposit are basic, semiacid, and carbonaceous varieties as a function of the chemical composition and refractoriness; they have medium and high plasticity. The clay is easily concentrated and is liquefied by traditional electrolytes (water glass and soda).

The mineral composition of the clay is kaolinitic and kaolinitic-quartz. The sintering temperature is 1250 – 1400°C, and the refractoriness is 1670 – 1760°C.

Belkino clays are characterized by high quality and relative consistency of composition and properties. We can assume that varieties that are white after firing at 1300°C can be used for production of commercial porcelain.

South Ural deposits of refractory clays have kaolinite-hydromica with montomorillonite, mineral composition and are finely disperse and highly plastic. A comparatively high iron oxide content is characteristic of them.

Refractory clays from the Nizhneuvel deposit are distinguished by important variability in both chemical composition and color in untreated form. The mineral composition is kaolinitic-hydromica: the kaolinite content is 60 – 80% and the hydromica content is 20 – 40%. The clays are finely disperse in granulometric composition. With respect to the alumina content, the clays are basic and semiacid. The clays are plastic and liquefy well. They sinter in the 1180 – 1250°C temperature range, and the refractoriness is 1650°C and higher.

Extraction is by the open method, by layers, and selectively. Five varieties are distinguished, and three are used as refractory raw material, including for production of different ceramic wares.

The Uprunsk refractory clay site is of special interest for quick prospecting of the deposit. The Al_2O_3 content is 38.8% and the Fe_2O_3 content is 1.65%. The sintering temperature is 1000 – 1200°C and the refractoriness is 1660 – 1710°C.

The South Ural (Berlinsk) refractory clay deposit is the largest in the Ural region. The mineral composition of the clays is kaolinitic with montomorillonite, hydromica, and mixed mineral of hydromica–montmorillonite composition. The iron oxide content varies within wide limits – from 0.9 to 6.0% and the Al_2O_3 content varies from 23.0 to 37.0%. The content of particles smaller than 1 μm is 49 – 90%. The clay is plastic and has a high content of soluble salts.

In dilution, the clay forms a suspension of higher viscosity than Nizhneuvel clay. When Berlinsk clay is used in manufacturing ceramic ware, it is expedient to use the filter-press method for preparing the paste. Berlinsk clays sinter in the 1250 – 1350°C range and their refractoriness is 1580 – 1740°C. The clay is used for manufacturing saggers and construction materials. In selective extraction, the clay has been used in production of commercial ceramics for preparation of resistor bases from low-alkali M-4 paste.

Refractory clays from the Buskul'sk deposit are a mixture of kaolinite (maximum of 60%) and monothermite (11 – 33%) and quartz, sericite, and feldspar contaminants. Buskul'sk clays have a high soluble salt content – chlorides and to a lesser degree sodium and magnesium sulfates, which easily pass into solution when the clay is washed. The content of particles less than 1 μm in size is 40 – 60%. The clay is plastic. The sintering temperature is 1180 – 1250°C, and some varieties sinter at a temperature of 1000 – 1200°C. The refractoriness is 1630 – 1710°C. Different samples of these clays differ little from each other, but differ significantly in the soluble salt content. The clays are used in production of saggers and majolica.

The mineral composition of *Kumaksk deposit refractory clays* is kaolinitic with mixed-layer formations of hydromica–montmorillonite composition and quartz as contaminant. The composition of the clay is primarily fine-washed. The content of particles less than 1 μm in size is 50 – 85%. Basic and semiacid clays are differentiated as a function of the alumina content. The refractoriness of variegated clays

varies from 1580 to 1650°C and the refractoriness of refractory clays varies from 1640 to 1750°C. The maximum sintering temperature is 1250°C. The clays are suitable for manufacture of refractories, tiles for interior walls, façade tiles, and acid-resistant pipes. Low-iron plastic varieties of the clays are light in color, almost white after firing at 1350°C, and can be successfully used in porcelain and faience pastes for manufacturing commercial and household products.

In testing KU-1 clay in fine-stone pastes, casting slip of satisfactory quality was obtained. Porcelain with 63% whiteness was obtained when Veselovsk clay was replaced by Kumaksk KU-1 in porcelain paste based on kaolin from the Zhuravlinyi Log deposit.

High-melting clays from the Kumaksk deposit (Bish-Obinsk section) have kaolinitic and montmorillonitic mineral composition. The contents are 50 – 75% kaolinite, 12 – 35% montomorillonite, 7 – 15% quartz, and under 6% iron hydroxides. The clays are distinguished by a high content of finely disperse iron oxides. The average alumina content is 29.0 – 31.0% and the average iron oxide content is 2.5 – 3.0%.

In granulometric composition, the clays are finely disperse. The refractoriness of the dark grey clays is 1610 – 1700°C, and the sintering temperature is 1100 – 1250°C; the refractoriness of the light grey sandy clays is 1650 – 1680°C, and the sintering temperature is 1250°C and partially does not sinter.

The clay is suitable for production of sewage pipes, acid-resistant brick, thermostable tiles, packing rings, facing tiles, and flooring tiles.

The clear-fired refractory clays from the Novo-Orsk deposit are kaolinite with hydromica contaminant. The aleurite and psammite fractions, whose content in the clays is up to 6 – 8%, are primarily represented by quartz. The grain size of the aleurite fraction is 0.05 – 0.07 mm and the psammite fraction is 0.2 – 0.5 mm in size. It contains 23.0 – 28.0% alumina, 0.9 – 1.4% TiO_2, and 1.1 – 1.7% Fe_2O_3. The content of particles less than 1 μm in size is 30 – 40%. The plasticity of the clay is 11.01; the color of the fired clay is cream with a pink tint. The clay sinters at 1250°C. The clay is suitable for production of sanitary ware, sewage pipes, flooring tiles, facade tiles, acid-resistant articles, and household ceramics. The clay is used in production at the Bun'kov Ceramics Factory.

Refractory clays from the Sedinsk deposit (Perm oblast) has a predominantly kaolinitic-hydromica mineral composition, and some varieties have montomorillonite impurities. The quartz content varies from 24 to 58%. It contains 14.0 – 22.0% alumina, 1.6 – 2.4% TiO_2, and 0.2 – 1.2% Fe_2O_3. The content of particles less than 1 μm in size is 36 – 70%. The plasticity number is 16.6 – 35.1. Most Sedinsk clays are distinguished by a low iron oxide content; despite the large amount of quartz, the fired color is white. The clays can be used in pastes for production of flooring tiles, sewage pipes, sanitary and commercial faience, and facing tiles.

The refractory clays from the Novo-Ivanovo deposit (Bashkiriya) are characterized by high plasticity and fine dispersion. The content of particles smaller than 1 μm is over 70%.

The clays consist of kaolinite with flakes of hydromica and very small grains of quartz. They contain 50 – 71% kaolinite, 3 – 18% hydromica, and 17% quartz. Some samples contain monothermite with kaolinite and montmorillonite. The Fe_2O_3 content is 0.5 – 2.0% (average of 1.5%) and the TiO_2 content is 1.5%. The refractoriness varies from 1500 to 1620°C and the sintering temperature is 1050 – 1150°C. The clays can be used for manufacturing sewage pipes, acid-resistant bricks, flooring tiles, and in pastes for production of sanitary and commercial porcelain and faience.

The following deposits could be of special interest for further studies of Ural clay raw materials.

Clays from the Gorodishchensk deposit are similar to Buskul'sk and Berlinsk clays with respect to the character and conditions of occurrence. The basic varieties of the clays are characterized by the following indexes: sintering temperature of 1200 – 1300°C, refractoriness of 1650 – 1730°C, moisture content of 23 – 26%, air shrinkage of 5.5 – 7.2%. The Al_2O_3 content is 21.5 – 33.5% and the Fe_2O_3 content is 0.2 – 0.5%.

The mineral composition of the *refractory clays from the Astaf'evsk deposit* is kaolinite-hydromica. The content of particles less than 1 μm in size is up to 41%. The $Al_2O_3 + TiO_2$ content varies from 15.0 to 40.0% and the Fe_2O_3 content is 0.6 – 2.4%. The sintering temperature is 1200 – 1350°C and the refractoriness is 1670 – 1760°C.

The *Kremenkul'sk and Alabugsk deposits* have not been explored and investigated. However, they merit attention. The area of the Alabugsk deposit is 50 ha and the depth is from 2 to 4 m. The clays are fat slate clays. The Al_2O_3 content is 34.0% and the Fe_2O_3 content is 1.8%.

Bentonite clays are used for multiple purposes in industry: in production of pellets in metallurgy, for muds in the petroleum industry, for reclamation of land contaminated with radionuclides in ecology, and in the ceramics and other industries.

Bentonites are finely disperse clay formations represented by aluminosilicates consisting of 80 – 90% well-crystallized dioctahedral montomorillonite with mixed-layer clay minerals and celadonite-glauconite micas as impurities.

The best known deposits of bentonite clays in the Ural are the Zyryanovsk (Kurgansk oblast), Berezovsk (Sverdlovsk oblast), Novo-Ivanovo (Bashkiriya), and others.

Work was begun in 2000 (at the initiative of NP Chelyabinsk Mine Management Co.) on a predictive estimation of the bentonite clay reserves in the eastern part of Chelyabinsk oblast for multipurpose use. The results of the semiquantitative analysis showed that the clay contains crystalline quartz (maximum of 50%) and smectite with mixed filling of gaps with monovalent (predominant form) and divalent cations (up to 40%) and hydromica of the illite type and

a x-ray amorphous substance. The chemical composition of the bentonite includes (%): 0.05 CaO, 1.12 MgO, 1.84 K_2O, 1.91 Na_2O. However, work has stopped due to lack of funding.

The proven world reserves of kaolin are 14 – 16 billion tons, including (billions of tons): 3.5 in the USA, 1.8 in Great Britain, 1.2 in China, 1.0 in Ukraine, 0.7 in Brazil, and 0.4 in the RF (Sverdlovsk, Chelyabinsk, Orenburg oblast). The potential reserves are approximately 1.0 billion tons for the east Orenburg oblast, and approximately 0.5 billion tons for Chelyabinsk oblast. Annual production is 0.7 million tons in the USA, approximately 100,000 tons in the RF, and demand is 800,000 tons.

Territorially, deposits of eluvial kaolins in the RF have been explored and worked only in the Ural. Searches for this raw material in other regions of Russia have not yet produced significant results. The Ural is thus the only supplier region in the RF for domestic consumers of kaolin products obtained in concentration of kaolin raw material. Of the eluvial kaolin deposits explored in Russia, only four have been worked: Nevyansk (Sverdlovsk oblast), Kyshtymsk, Eleninsk, and Zhuravlinyi Log. Reserves – Chekmakul'sk and Poletaevsk (Chelyabinsk oblast) are taken into account in the state balance sheet in addition to these deposits.

The prospects for increasing the kaolin raw-materials base in the Chelyabinsk oblast are unlimited. Category P_2 reserves in the amount of 30 million tons within the boundaries of the Kyshtymsk kaolin region, 46.6 million tons in the Chelyabinsk region, 60 million tons in the Kochkarsk region, and 45 million tons in the Dzhabyksk region have been tested. In addition, the predicted category P_3 reserves are 354 million tons in 10 promising areas primarily confined to the region of development of the main Ural granite belt. The eastern Orenburg oblast (Orskoe Zaural'e) has important predicted eluvial kaolin reserves (approximately 0.5 billion tons).

In this respect, development and improvement of the kaolin mineral raw-material base in the Ural is exclusively of federal importance. For this reason, The Target Program for Development of the Kaolin Mineral Raw-Material Base in the RF for 2000 – 2010 provides for geological exploration in the territory of the South Ural region based on the exploration, search for, and identification of categories $P_1 + P_2$ kaolin reserves. However, note the lack of any program for the comprehensive investigation of the raw materials for the applicability and composition and properties of the kaolins. We believe that collaboration between geologists and research organizations must be developed and strengthened to successfully solve all of the problems related to forming a kaolin mineral raw material base.

Together with geologists, we have conducted a series of studies in recent years on promising new deposits of kaolins in the South Ural region – Severo-Ushkotinsk, Yuzhno-Ushkotinsk, Kiembaev, Kotansinsk, Soyuz, Poletaevsk, and Georgievsk.

Since there are sufficient communications on the *Zhuravlinyi Log kaolin deposit* and it is not the only source of high-quality kaolins, it is only necessary to provide information on the complicating factors related to insufficient investigation of the variability of the composition and properties of the kaolins revealed during preliminary exploration of the deposit. After completion of assessments on the flanks of the deposit, the reserves were increased by approximately 60 million tons, including 16 million tons for fine ceramics and 37 million tons for the paper industry. However, in performing these assessments, methods of investigating the composition and properties of the kaolins were not fully utilized, so that the deposit was assigned to the category of insufficiently investigated deposits. It is very probable that complications could arise in working it due to the incomplete information on the variability of the composition and properties of the kaolins within the boundaries of the exposed deposits.

Consumption of *kaolin from the Eleninsk deposit* has significantly increased in the ceramics industry in recent years. In concentrated kaolin, the Al_2O_3 content is relatively high (38.61%). The mineral and chemical compositions of all varieties of kaolin are very close. The plasticity number is 5.0 – 6.9 and the crystallinity index (Henkel) is 1.19. The kaolin has a more perfect structure than the kaolins from Ukraine. Studies of the rheological properties of kaolin and practice in its wide use in many enterprises showed that Eleninsk kaolin can be used in production of fine ceramics (household and commercial porcelain, construction ceramics). The casting properties of the slip are satisfactory. The quality of the casts is better at a slip moisture content of 38% and when tannate is used as the electrolyte (0.3%).

Properties of Concentrated Eleninsk (Unsintered) Kaolin

Water absorption, %, at firing temperature of, °C:	
1350	19.4
1380	16.8
Total linear shrinkage, %, at firing temperature of, °C:	
1350.	11.1
1380	12.8
Bending strength, MPa, at firing temperature of, °C:	
1350	20
1380	25
Whiteness, %	91.3

The samples of kaolin fired at these temperatures were white with no specks or melting.

Kyshtymsk Kaolin is of much worse quality than kaolins from the Zhuravlinyi Log and Eleninsk deposits. However, it is totally suitable for production of electrical porcelain and household and sanitary-construction ceramics.

The explorations conducted within the boundaries of the Verkhne-Ushkotinsk area in 1999 – 2001 revealed the *South-Ushkotinsk kaolin deposit* which was transferred to the state reserve. The predicted reserves for categories $C_1 + C_2 + P_1$ are 52,361,000 tons and the alkaline kaolin reserves are 22,494,000 tons. The quality of the ore is high.

The commercial mineral is especially correlated with the kaolin zone consisting of two subzones – normal and alkaline kaolins (see Table 1).

TABLE 1

Minerals	Mass content, %	
	in raw material	in alkaline kaolin
Kaolinite	45 – 65	30 – 35
Quartz	30 – 52	45 – 20
Microcline	1 – 2	18 – 20
Muscovite	1 – 3	1 – 2
Other	1 – 3	1 – 2

The chemical composition of the washed kaolin is (%): 46.14 – 46.50 SiO_2, 36.01 – 37.80 Al_2O_3, 0.53 – 0.75 Fe_2O_3, 0.08 – 0.11 TiO_2, 0.51 – 0.88 K_2O.

With respect to the content of coloring iron and titanium oxides, the kaolin is high-quality and satisfies the requirements of GOST 21286–82.

The bending strength (MPa) is: dry kaolin raw material, 1.3; after firing at 1350°C, 26; washed kaolin in the dry state, 2.1; after firing at 1350°C, 38.6. The confirmed reserves for categories $C_1 + C_2$ are 38.5 million tons.

The *North-Ushkotinsk deposit* is part of the Ushkotinsk kaolin-bearing region. The predicted reserves are 31 million tons. The kaolins are not flooded and the quality is sufficiently high.

The mineral composition of the kaolin raw material (%) is: 40.0 – 60.0 kaolinite, 39.0 – 48.0 quartz, 4.0 – 10.5 microcline, 0.0 – 8.0 muscovite. The $Al_2O_3 + TiO_2$ content is 34.02 – 36.60 and the Fe_2O_3 content is 0.68 – 0.95. The bending strength in the dry state is 1.0 – 2.3 MPa and the fired bending strength is 22.0 – 60.0 MPa. The whiteness is 78%.

For a long time, *kaolin from the Poletaevsk deposit* was counted in the reserve balance – semiacid raw material with a high large-grain quartz content for production of chamotte refractories. The kaolin is coarsely disperse, is similar to Eleninsk kaolin in grain composition, and has low plasticity. The conditional differences relate to unsintered kaolins. Despite the alkaline oxide impurities (K_2O, Na_2O) which attain 3 – 6%, the sintering temperature of the kaolins is 1500°C, which is probably due to their coarse dispersion.

The mineral composition of concentrated kaolins is (%): 70 – 80 kaolinite and halloysite, 10 – 15 hydromica (hydromuscovite), 7 – 10 quartz. The kaolin is easily concentrated.

Ceramic and Process Properties of Poletaevsk Kaolin

Water absorption, %, at firing temperature of, °C:
- 1350 . . . 7.8
- 1450 . . . 5.1

Total linear shrinkage, %, at firing temperature of, °C:
- 1350 . . . 9.39
- 1450 . . . 10.27

Refractoriness, °C . . . 1720 – 1770

Whiteness, %:
- after drying at 110°C . . . 83 – 87
- after firing at 1350°C . . . 82 – 89

Test results suggested that the kaolin which is raw material for the refractories industry can be successfully used in production of household ceramics, construction materials, and other areas where rigorous requirements are not imposed on the material and grain compositions of the raw material. The categories $A + B + C_1$ kaolin reserves are 28.8 million tons.

Beds of alkaline kaolins have been discovered in the Central Ural region. It is expedient to conduct a complete study of the known deposits: Chekmakul'sk, Mikhailovsk, Chuksinsk, Zhuravlinyi Log, Kyshtymsk, and Poletaevsk, and to assess the raw material quality of such kaolin deposits as Uktussk and Nyuksinsk (Sverdlovsk oblast), Yul'evsk, Kotlik, Neplyuevsk, and Letnie Khutora (Chelyabinsk oblast).

In the Orenburg oblast, most of the kaolins from the Dombarovsk deposit also belong to the alkaline variety.

A pressing problem in the near future is to create industrial reserves of alkaline kaolins in the Ural as they have almost not been investigated. The study and exploration of nonmetalliferous raw materials in the Ural with the development of methods of using it in practice could be the basis for organizing production of scarce materials in the region both for ceramics enterprises and for refractory and glass companies. Most deposits of nonmetalliferous materials have been explored in detail and are of industrial importance with respect to reserves.

Attention should especially be focused on the exploration and study of feldspars and their substitutes, since the existing suppliers are not capable of satisfying the growing demand for them.

Feldspars constitute a large group of potassium, sodium, calcium, and less frequently barium aluminosilicates widely represented in the Earth's crust (up to 60%) by minerals – orthoclase (microcline), albite, anorthite, etc. The basic consumers are the glass, porcelain-faience, construction ceramics, electrical, and electrical insulation industries. Feldspar raw material is used in smaller quantities in the abrasives, chemical, and electronics industries, in production of welding electrodes, etc. The large number of consumers is responsible for both the very different applications (flux, alumina and alkaline components, inert filler) and the variety of limiting raw-material quality indexes with respect to the mineral and chemical compositions, degree of grinding, etc., which are regulated by the corresponding standards.

In natural form, feldspar rocks usually do not satisfy the requirements imposed in industry on the quality of feldspar products. Their industrial extraction is possible and economically expedient only from a comparatively small number of genetic types of rocks of feldspar (syenites), quartz-feldspar (pegmatites, granites, sands, etc.), nepheline-feldspar (nepheline syenites, miascites), kaolinite-feldspar-quartz (sands, kaolinized granitoids, altered vulcanites, etc.) compositions encountered in deposits frequently thousands of kilometers away from the users.

The basic explored and worked feldspar deposits are located in Karelia, Siberia, and the Ural region.

The ever-increasing demand for feldspar raw material is still not completely satisfied.

Within the boundaries of the Ural region, there is an important number of feldspar raw material deposits represented by pegmatites, granites, aplites, granitoids, nepheline-syenites, miascites, etc., which require concentration and are not being developed at present. Special prospects should be correlated here with organizing associated production of high- and low-potassium feldspar concentrates which would allow totally satisfying the demand for raw material not only for local but also for other enterprises.

The *Vishnevogorsk deposit* is the leading explored and investigated feldspar and pegmatite deposit with respect to reserves and quality. Microcline-pertite predominates in pegmatites. Nepheline syenite (under 9%) is observed. Egirine impurity is present in the form of individual crystals and aggregations. Vishnevogorsk Mine Management manufactures feldspar and nepheline–feldspar concentrates. This product is used by more than 70 enterprises in the RF and CIS countries. It is one of the basic components in production of window and showcase glass, for manufacturing color and black-and-white picture tubes, medical instruments and vessels, welding electrodes, in the abrasives industry, and in production of ceramic tiles and other kinds of construction ceramics and glazes.

Feldspar and nepheline-feldspar concentrates have no domestic and foreign analogs, since they are distinguished by a high and stable aluminum (minimum of 20%), potassium (5 – 6%), and sodium (7 – 8%) oxide content. Production and sale of the concentrates are less than 500,000 tons a year, but this is insufficient for satisfying the demands of industry for this kind of raw material.

Malyshevsk Mine Management is second in importance in the region. Feldspar is represented by microcline and albite, a maximum free quartz content of 10%, a minimum content of potassium and sodium oxides of 11%, and an aluminum oxide content of 18.0 – 19.5%; the iron oxide content (Fe_2O_3) varies from 0.2 to 0.5%. The production capacities allow producing up to 120,000 tons of feldspar concentrates a year, used for manufacturing faience, majolica, construction ceramic materials, and glass.

Of the group of Alapaevsk feldspar deposits, the Severnaya Mel'nitsa, Alabashsk, Tysyachnitsa, and Vatikha deposits merit attention. Pegmatites consist of feldspars (60 – 65%), quartz (30 – 35%), and biotite (5 – 10%). Concentrates with a 0.19 – 0.21% iron oxide content are obtained in concentration of pegmatite.

Sokolovsk feldspar (Rezhevskaya Dacha) is significantly eroded, brittle, crumbles easily, and breaks up when lightly struck with a hammer. The color is light grayish-white. The spar is slightly kaolinized and relatively clean, fires at 1350°C, and has good whiteness.

The *feldspar from the Ostaninsk deposit* is totally acceptable in production of porcelain and faience on insignificant culling.

Alaskaites from the Rezhik deposit consist of feldspars (65 – 72%), quartz (27 – 32%), muscovite (1 – 3%), kaolinite (1 – 2%), and garnet (0.0 – 0.5%). Alaskaites are used without concentration at the Kosulinsk Abrasives Factory, Nev'yansk Ceramic Tile Factory, and Uralelektroapparat Factory for coating electrodes.

Granites (alaskaites and aplites) from the Rezhik deposit are suitable as valuable feldspar raw material in natural form for manufacturing sewage pipes and flooring tiles. After electromagnetic separation, grade 1 raw material can be used for production of glass and fine ceramics, including high-voltage porcelain. The yield of concentrate is approximately 90% with a 0.09 – 0.15% Fe_2O_3 content.

The Ural is rich in veiny quartz, quartz sands, and marshalite. However, these materials have not been explored and studied in detail as ceramics raw materials. The purest veiny quartz materials are found in the Bilimbaevsk, Nev'yansk, and Zlatoustovsk regions. The silica content is 99%, and the total sesquioxides is under 0.26%.

Sands from the Malyshevsk, Vozdvizhensk, Kyshtymsk, Svetlinsk, Iraklinsk, Kulikovsk, and other deposits and powdered quartz (marshalite) from the Bolotovsk, Nagaivaksk, Arkhangel'sk, Taktubaevsk, Bald Mountain, and other deposits can be used as replacements for quartz sands from the Ul'yanovsk deposit.

The absence of free metallic iron is the basic advantage of powdered quartz. There is no radiation background.

Saraktashsk Porcelain Factory uses powdered quartz in the paste composition. Yuzhnoural'sk and Bogdanovich Porcelain Factories have also tested powdered quartz in pastes. The paste grinding time was reduced by 4 h. The results of the test were positive. The articles satisfy the requirements in GOST 28390–89. Powdered quartz from the Taktubaevsk deposit have also been used in faience pastes.

The demand for highly refractory ceramic materials with a high Al_2O_3 content raises the problem of using new kinds of raw materials in production, including kyanites (disthenes).

Refractories made from kyanite concentrates have advantages over quartz, high-alumina, and other refractory materials. Due to the high Al_2O_3 content, kyanite can be used in production of aluminum-silicon alloy (silumin) and metallic aluminum.

Incorporation of 30 – 60% kyanite or its analogs (sillimanite, andalusite) in porcelain paste (firing temperature above 1400°C) allows manufacturing articles with high bending strength (up to 140 MPa) and thermal stability, as well as with important electrical resistance at high temperatures.

At least 20 showings of kyanite ore of industrial interest are located in the Ural region. The reserves at Sosnovsko-Abramovsk, Sysertsk, Brusyansk, and Karabashsk kyanite areas alone have been estimated at 28 million tons.

Pyrophyllite is a laminar hydrated aluminosilicate $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$. All types of pyrophyllite raw material are known in the Ural region. Deposits that should be investi-

gated are the Chistogorovsk, Kul'-Yurt-Tau, and Gaisk deposits.

The *pyrophyllite raw material from the Kul'-Yurt-Tau deposit* is represented by different types and all types of the raw material are low-iron. The pyrophyllite-quartz composition of the raw material is most widespread. The raw material has been used in paste compositions for sewage floor tiles and heat- and acid-resistant tiles. In the laboratory conditions of the Yuzhnoural'sk Porcelain Factory, pyrophyllite-containing raw material has been tested in pastes for household porcelain. The quality of the articles is satisfactory.

The mineral composition of *Gaisk pyrophyllite raw material* is (%): 50 pyrophyllite, 45 quartz, 5 sericite. The raw material has been tested in production of different ceramic articles – facing tiles, electrical porcelain, chamotte refractories, and in pastes for acid-resistant articles.

It is thus justified to speak of Ural pyrophyllite raw material as a potential source for the ceramics and refractories industries.

Titanium ores are basically located in the South Ural and are represented by industrial titanomagnetite ores of both bedrock and loose occurrence. Titanium deposits appear in pegmatites from the Il'men, Shishim, and Nazyam Mountains. With respect to the genesis, the deposits are endogenous and exogenous. Ilmenite-magnesite ores from the Kusinsk section are endogenous. The ores are made up of magnetite (60 – 70%), ilmenite (20 – 30%), and chlorite (2 – 10%).

At the Kusinsk-Kopansk group deposits, with a flank content of 5% titanium, the predicted resources in ilmenite, titanomagnetite, and ilmenite-titanomagnetite ores based on category P_1 are hundreds of millions of tons. The most valuable sections have been explored, and the reserves have been brought up to industrial categories or to categories C_2. The large predicted category P_3 resources of endogenous titanium are correlated with gabbro massifs in the southeast Chelyabinsk oblast. It still requires investigation.

Titanium mineral placers have been established in the western Chelyabinsk oblast in the Atlyan region, Yaumbaevsk ore showing, in the coal-bearing deposits of the Poltavo-Bredinsk region, and in the region of the Kusinsko-Kopyansk group of deposits. The predicted placer resources range from hundreds of thousands to several million tons of titanium dioxide.

Zirconium veins are known in the Il'men and Vishnev Mountains in the Ural. Placer deposits are located in the South, Central, and North Ural.

Placers in the South Ural deposit are now of practical importance. Vishnevogorsk MCC Ltd. mines the titanomagnetite found in the deposit together with zirconium.

Chromite (chromium ore) is rock made up of chromospinelides. In nature, the mineral chromite $FeO \cdot Cr_2O_3$ in pure form usually does not form bodies. Chromite deposits are located in the Perm' (Saranovsk), Sverdlovsk (Golorodsk, Alapaevsk, etc.) oblasts and in Polyarny Ural, in Yamalo-Nenetsky national district, and on the eastern slope of the south part of the Ural (Kimpersaisk, Kazakhstan).

The predicted resources of chromite deposits in the Ural region are 240 million tons, including 20 million tons in the Perm oblast, 170 million tons in the Sverdlovsk oblast, and 50 million tons in the Orenburg oblast.

Graphite is one variety of native carbon. Crystalline and amorphous graphite is usually distinguished in industry.

One of the largest graphite deposits in the RF is found in the Ural. The Central and South Ural contains 34.8% of the ore reserves in Russia. Graphite is mined in the Ural at the *Taiginsk deposit* of crystalline graphite, and 22.4% of the graphite ore reserves and 7.4% of the graphite reserves in the RF are concentrated in it.

Many showings of graphite are known in the Kochkarsk region. The group of Chesmensk showings of graphite in the Port-Arthur, Tolstinsk, and Potapovsk section merits special attention. The predicted category P_2 resources constitute 13.85 million tons. The *Boevsk deposit* (Bagaroksk region) is of great industrial importance. The graphite content in the ore is up to 45% and in some cases up to 78%.

Mining of graphite ores in the Taiginsk deposit in 2001 consisted of 352,000 tons of ore and 10,800 tons of graphite.

The large *Murzinsk deposit* has been explored in the Sverdlovsk oblast. Construction of a concentration plant with a capacity of 5.4 million tons of graphite concentrate a year has been proposed. In concentration of the ore, feldspar concentrate is obtained as a by-product. Production of 50,000 tons a year (primary) is planned.

More than 15 deposits of dolomite are known in the Ural. Industrial mining is now being conducted in five deposits in the Perm, Sverdlovsk, and Chelyabinsk oblasts. Dolomites from the Lis'egursk (Chelyabinsk obl.) and Kvarkensk (Orenburg obl.) deposits have the lowest impurity content. The total reserves are more than 72 million tons.

Magnesites – a very valuable raw material for production of refractories – are concentrated in the Satkinsk group of deposits, the Khalilovsk amorphous magnesite deposit (Orenburg oblast), and in the Republic of Bashkortostan.

Magnesium silicates, together with clays and silica, are some of the most important kinds of ceramic raw materials. In contrast to magnesite, magnesium silicate deposits are widely distributed, and the reserves are usually billions of tons.

The dunite-serpentinite belt, the basic representative of this raw material, has been traced from the Polar to the South Ural. The Iovsk (Kotylmsk), Ukgussk, Solov'evogorsk, Bazhenovsk, Saranovsk, Shabrovsk, and others are the most interesting deposits.

In conclusion, we need to have a national program for creating a RF mineral-raw material base which would not only fund geological exploration and would revive one research institute to study raw materials, develop new manufacturing processes, and create highly productive equipment as well as constructing modern concentration complexes to successfully utilize the riches of the Ural.